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Autoclaved aerated concrete

Lightweight concrete can be produced by using lightweight aggregates, by 'aerating' with gas bubbles, or by eliminating fine aggregate from the mix to produce 'no-fines' concrete. This digest gives information about the properties and uses of autoclaved aerated concrete. It supersedes Nos. 16 and 17 which are now withdrawn. Lightweight aggregate concretes are dealt with in Digests 111 and 123.

Short description

Autoclaved aerated concrete is a uniform cellular product made from a siliceous material (eg sand and/or pulverised-fuel ash) and cement or cement and lime. The cellular structure, which provides good thermal insulation properties, is produced usually by the incorporation of fine aluminium powder into the mix. This reacts with lime or other alkaline substances that are either formed by the setting of the cement, or added deliberately, to produce bubbles of hydrogen. The cell walls are composed of siliceous particles bound together by a crystalline form of calcium silicate hydrate. The nature of the siliceous material is generally identifiable by the colour of the finished product; ground sand produces a white material and pulverised-fuel ash a grey material.

Strength and drying shrinkage characteristics acceptable for loadbearing purposes are attained by high-pressure steam curing ('autoclaving'), after which no further curing is required.

Properties

Density and strength Autoclaved aerated concrete is made in the dry density range of 500–1000 kg/m³; for reinforced, structural, purposes, material of density 550–650 kg/m³ is normally used.

Table 1 Strength and elasticity of autoclaved aerated concrete products

Dry density	Typical compressive strength (tested wet)	Modulus of elasticity
kg/m³	*N/mm²*	*N/mm²*
500	2·8	1400
600	3·5	1800
750	3·5	2800
800	4·2	3200
830	4·5	—
880	6·0	—

Table 1 gives a guide to the minimum compressive strengths to be expected from various densities of autoclaved aerated concrete. The lowest average strength for a Type B block is quoted in BS 2028, 1364: 1968 as 2·8 N/mm².

Modulus of elasticity The modulus of elasticity is about one tenth that of dense concrete; typical values are given in Table 1.

Creep Aerated concrete, like other cement products, undergoes plastic deformation, or creep, under sustained loading. Experimental work indicates that under normal conditions the creep at working loads is not greater than with dense concrete.

Drying shrinkage BS 2028, 1364: 1968 specifies maximum drying shrinkages of 0·07 to 0·09 per cent, depending on type and density, when tested in accordance with the Standard. The shrinkage in drying from delivery moisture content to equilibrium moisture content can be as low as 0·02 per cent, but to obtain such a low level of shrinkage care should also be taken to prevent the blocks from becoming excessively wet on site.

Thermal insulation An important feature of the material is its low thermal conductivity, this being

Table 2 Thermal conductivity (k): average values for concrete (from Digest 108)

Concrete type	Density	k-value at moisture content 3 per cent	5 per cent
	kg/m³	*W/m°C*	*W/m°C*
Lightweight	500	0·16	0·18
	600	0·19	0·20
	700	0·21	0·23
	800	0·23	0·26
	900	0·27	0·30
	1000	0·30	0·33
Dense	2100	1·28	1·41

Note Measured k-values should be used in preference to the above, when available.

roughly proportional to the density. Table 2 compares typical *k* values of some grades of lightweight concrete with dense concrete. Aerated concrete in service as the inner leaf of a cavity wall or as a roof can be assumed to have a moisture content of about 3 per cent, by volume.

Fire resistance A 100 mm wall of autoclaved concrete blocks, without surface finishes, has a fire-resistance grading of two hours if loadbearing, or four hours if non-loadbearing. These performances may be improved, or the thickness for the same performance reduced, by applying suitable surface finishes such as gypsum-vermiculite plaster. The fire resistance of reinforced units varies from one to six hours, depending on the type, thickness, loading and the cover to the steel.

Sound insulation and absorption The sound insulation afforded by an aerated concrete partition depends on the density and thickness of the units and is much the same as that of other concretes of similar density. Plastering the wall on both sides improves the insulation by increasing the weight and sealing the joints between units. The sound absorption is higher than that of dense concrete but the difference is of little practical significance when the surface is plastered.

Resistance to rain penetration Aerated concrete blockwork rendered externally, and reinforced wall units with an approved surface treatment, have been subjected to the standard artificial rain test (BS 4315: Part 2) for periods up to 14 days without showing water stains on the back face and this is confirmed by field experience; aerated concrete, in some instances without surface protection, has shown satisfactory resistance to rain penetration except in the most exposed conditions where many other materials would likewise fail.

It is, however, always advisable to keep the material as dry as possible by means of a rendering or some other equally effective coating, so as to maintain its thermal insulating value. Although in reinforced units the reinforcement is specially protected against corrosion, keeping the units dry is a further safeguard.

Frost resistance Subject to some limitations on the use of blocks below ground-level damp-proof course, the material can be considered to be frost-resistant under the conditions normally encountered in this country.

Cutting and nailing The material is easily sawn and drilled with hand tools. Chases for services can be formed on site. Secure fixings can be made with cut nails, woodscrews, wall plugs and certain proprietary anchor fixings. The block manufacturer can usually advise on the most appropriate method.

Other properties

Vapour resistivity	60 MNs/gm
Specific heat capacity	1.0 kJ/kg °C
Coefficient of linear thermal expansion	8×10^{-6} °C

Uses

The structural use of autoclaved aerated concrete was originally developed in Scandinavia and has been extended considerably in many other countries, including the United Kingdom, during the past 20 years.

The material is produced in two main forms:

Building blocks Used in solid and cavity wall construction; backing to external cladding and curtain walling; infill panels to framed structures; internal loadbearing and non-loadbearing walls

Reinforced units Structural roof and floor units; loadbearing and non-loadbearing external walling and internal partitions; complete structural shells for hospitals, hotels, housing, etc.

More recent developments include precast lintels, infill blocks for concrete floor and roof systems, blocks faced with cast stone, and the use of certain types of blocks below dpc in external walls where there is an Agrément Certificate or other authoritative evidence.

Precast building blocks

Blocks are made in various sizes and densities and are covered by BS 2028, 1364: 1968 *Precast concrete blocks*.

For external walls of cavity construction, some manufacturers state that the blocks are suitable for both the outer and inner leaves, others for the inner leaf only; in the latter case, any normal walling may be employed for the outer leaf. When used for the outer leaf, the blocks should preferably be rendered or otherwise protected to reduce water absorption. As with other materials, care should be taken in the design of flashings, etc, to prevent the entry of water at vulnerable points. Apart from the possibility of moisture penetration to the inner face, wetting the material temporarily reduces its thermal insulation value.

Use below damp-proof course BS 2028, 1364: 1968 divides loadbearing concrete blocks into two broad categories (redefined in the 1968 edition) based on density:

Type A: not less than 1500 kg/m^3

Type B: less than 1500 kg/m^3

(A third type C, is intended only for use in internal non-loadbearing walls)

Type B blocks are only recommended for general use below the ground-level damp-proof course in the outer leaf of a cavity wall, or in an external solid wall,

if they have an average compressive strength of at least 7·0 N/mm² or are made with dense aggregates (ie complying with BS 882 or BS 1047). This usually excludes the use of autoclaved aerated concrete blocks for this position unless authoritative evidence of their suitability, such as an Agrément Certificate, can be supplied.

Where ground water conditions are such that precautions have to be taken against sulphate attack on concrete footings (*see* Digest 174), autoclaved aerated concrete blocks would not normally be recommended for use below damp-proof course.

Structural use The structural recommendations for loadbearing masonry walls included in CP 111 are applicable to aerated concrete block walls. The lowest average strength recommended for blocks is 2·8 N/mm², tested wet. While strengths of this order may be adequate for domestic construction, the strength specified for any given purpose should be chosen according to the loads to be carried and the thickness needed to give the thermal, fire and sound insulation required. Details of the properties and use of aerated concrete blocks are given in the manufacturers' technical literature.

Contraction joints In long unbroken lengths of block walling, vertical contraction joints should generally be provided at intervals of about 6 m. They may be formed during construction or by cutting into the blockwork, when it has attained sufficient strength, up to one third of its thickness.

Mortars As with other types of concrete blocks, the use of strong mortars in aerated concrete blockwork is bad practice. Weaker mortars distribute the effects of movements due to drying shrinkage and other causes and so help to prevent cracking. For most internal work, a 1:2:9 mix of cement, lime, sand is sufficiently strong; alternatively, a 1:5–6 mix of masonry cement and sand, or a 1:6 mix of cement and sand with a water-retaining agent may be used.

Plastering and rendering Aerated concrete may contain up to 15 per cent (by volume) of moisture when delivered to the site and can take up more if exposed to the weather in the stack or during construction, thereby increasing the likelihood of shrinkage cracking; if it is plastered too soon, the plaster is likely to crack. The obvious precautions are to see first that the materials do not become needlessly wet in storage or in use, and to defer plastering until most of the drying shrinkage has taken place. Heating appliances can be used to hasten the drying, especially in winter, but heating needs to be accompanied by good ventilation (*see* Digest 163).

Some of the lighter grades of aerated concrete have a high suction which may make it more difficult to ensure good adhesion of plaster or rendering. It is not desirable, for the reasons explained earlier, to try to overcome this by wetting the surface excessively. However, satisfactory results can be obtained for internal plastering by the application of a bonding agent before plastering, or by using one of the special plasters that have been developed for the purpose. For external rendering, high suction can be overcome by applying a spatterdash of 1:2½ cement and sand an hour or two before rendering. Alternatively, a water-retaining agent may be added to the plaster or rendering mix, though some brands of aerated concrete contain additives which make this unnecessary.

For external rendering, a cement and sand spatterdash (if required) can be followed after one to two hours by an undercoat of cement, lime and sand ranging in composition from 1:1:6 to 1:2:9 by volume, according to the season, the degree of exposure and the density of the blocks. The finishing coat can be of the same composition. Other decorative and protective treatments can also be applied. The makers of the blocks are prepared to advise on plastering and decorative treatments suitable for their own products.

Low-temperature insulation Blocks of the normal density grades may be used for low-temperature insulation; special low-density grades are available from some manufacturers. They should be dried, if necessary, before use and careful design precautions should be taken to avoid moisture build-up due to interstitial condensation. The blocks should be laid in an air-entrained or other lightweight mortar, to ensure that the thermal transmission of the joints is similar to that of the blocks.

Precast blocks or structural roofing units can also be used for the roof construction.

Precast reinforced units

The scope of aerated concrete in building construction has been extended considerably in recent years by the successful production of autoclaved reinforced units in a variety of forms, including flexural members spanning up to 6 m and capable of carrying a wide range of loadings. Manufacturers have paid special attention to the problem of protecting the reinforcement from corrosion and have developed proprietary treatments which are applied to the steel before the concrete is cast; these are effective in normal conditions of exposure in building. Reference should be made to CP 116:Part 2:1969 (Section 8).

Reinforced floor, partition, roof and external wall units have, for a number of years, been manufactured in the United Kingdom in the range of sizes shown in Table 3. Normally, each manufacturer produces in one standard width only. Designers should avoid the use of non-standard widths and the number of different lengths should be kept to the minimum. The use of storey-height door and window frames and unit width roof lights will simplify design.

Table 3 Range of sizes of reinforced units currently manufactured in the United Kingdom.

Type	Length	Width	Thickness
	mm	*mm*	*mm*
Roof and floor units	up to 6220	600	75–225
Horizontal wall units; non-loadbearing	up to 6220	600	125–225
Vertical wall units; load-bearing	up to 6220	600	100–225
Partition units; non-loadbearing	up to 2750	600	75
	up to 3750	600	100
Lintels	up to 2100	215 222	75, 100, 150, 200, 225, 250
	2100 to 2700	215 222	150, 200, 225, 250

Reinforced units are made in modular sizes for use in open systems of industrialised building. The largest use is for industrial and other flat roofs (houses, hospitals, schools) on account of lightness, thermal insulation, non-combustibility and speed of erection. Special consideration must be given to the detailing of the roof construction where the units are to be used over areas of unusually high humidity and temperature, to prevent excessive interstitial condensation.

Finishes Roof slabs are generally laid with falls incorporated in the structure so that the roof can be waterproofed with bitumen felt or asphalt without screeding. Soffits of roof and floor slabs must have a vapour-permeable finish, such as emulsion paint.

The external finish of walls should be vapour-permeable; masonry paints are often used, with the joints expressed in the finish. The degree of protection needed, coatings, renderings or claddings, is related to the driving rain index (*see* Digest 127).

Internal walls are usually finished with a skim coat of plaster but may be painted or finished with wallpaper or other sheet material, directly applied.

Handling The cellular structure of aerated concrete, which makes it light to handle and easy to work, makes it susceptible to damage during transport and erection. Reinforced members, if damaged sufficiently to expose the reinforcement, can deteriorate and site operations should be strictly supervised to ensure that structural members are handled with due care; they should not be allowed to stand exposed to the weather.

Manufacturers have developed numerous devices to facilitate handling, erection and protection of the units, and also various drilling and cutting tools.

Documents referred to in the text

BRE Digests

108 Standardised U-values
111 Lightweight aggregate concretes: structural applications
123 Lightweight aggregate concretes
127 An index of exposure to driving rain
174 Concrete in sulphate-bearing soils and groundwaters

Codes and Standards

CP 111: Part 2: 1970 Structural recommendations for load-bearing walls

CP 116: Part 2: 1969 The structural use of precast concrete

BS 882, 1201: Part 2: 1973 Aggregates from natural sources for concrete (including granolithic)

BS 1047: Part 2: 1974 Air-cooled blastfurnace slag coarse aggregate for concrete

BS 2028, 1364: 1968 Precast concrete blocks

BS 4315: Part 2: 1970 Permeable walling constructions (water penetration)

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